

Hazelnut

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Scientific Name and Introduction: *Corylus avellana* L., the filbert or hazelnut is a member of the birch family (Betulaceae). The edible seed is surrounded by a round to slightly oblong shell that must be separated from a husk during or after harvest. All important world cultivars originated from human selections of wild *C. avellana* in Europe and Turkey. The common name “filbert” originated in England and was originally applied to the long husked types of *Corylus avellana* to distinguish them from the short husked types, and has since been used in the U.S. to distinguish the cultivated *Corylus avellana* from other native wild species of *Corylus*. The common name “hazelnut” is more commonly applied world-wide, for nuts produced by all *Corylus* species and will be most commonly used in these guidelines.

Two wild species, *C. americana* and *C. cornuta*, are found in the U.S. *C. americana* has been used in breeding programs for crossing with *C. avellana* in attempts to provide genotypes with sufficient cold hardiness and eastern filbert blight tolerance or resistance to allow production east of the Rocky Mountains with some success. Whatever the chosen common name, nuts from this genera represent one of the world’s major nut crops, second only to almonds (Thompson et al., 1996). Turkey produces most of the world supply (70%), followed by Italy (22%), Spain (5%) and the U.S. (3%). By far the largest production area in the U.S. is the Pacific northwest, with 99% of production occurring in the Willamette Valley of Oregon (Mehlenbacher and Olsen, 1997). Market uses for the U.S. crop has been roughly evenly divided between in-shell and kernel markets, but trends are shifting towards kernel markets. The major variety in the U.S. is Barcelona, followed by Davinia, Ennis and Willamette.

Quality Characteristics and Criteria: In-shell hazelnuts should be properly sized to meet the stated market type and should be properly filled with at least 50% of the shell cavity occupied by nutmeat. Shells should be free of cracks and noticeable mechanical injury, clean, brightly colored and coloring patterns should be characteristic of the stated variety. The pellicle should be smooth and devoid of husk attachments. Kernels should meet the stated market type, be free of any misshapen or underdeveloped kernels and be free of any shell or foreign material and off-odor, off-flavor or mold. Water content of kernels should not exceed 6% if shelled or 7% if in-shell, and the total water content of unshelled nuts should not exceed 10 to 12%. Size is specified with grade as a determinant of quality, and minimum sizes are used for specification of classes “Extra” and “Class I” in international trade. For in-shell markets, larger and particularly rounded types are preferred. Shelled markets accommodate both rounded and oblong types, and size preference is dependent on the intended end use. Hazelnut kernel oil content ranges from 57 to over 70% and total sugars average about 4% and both vary with variety and growing location (Botta et al., 1994). Hazelnuts are highest among tree nuts in α -tocopherol content (366 $\mu\text{g/g}$ oil) and are also a rich source of vitamin B₆ (0.54 to 0.89 mg per 100 g) (Richardson, 1997).

Horticultural Maturity Indices: In areas where hazelnuts are mechanically harvested, nuts are usually allowed to naturally drop from trees prior to sweeping from the orchard floor, and harvesting may commence after 90% of the nuts have dropped (Lagerstedt, 1979). Kernels are considered mature after oil accumulation is complete and when the nut detaches from the base of the husk (Thompson et al., 1996). In the U.S., most nuts are mature during or by the end of August, but may be prevented from dropping by an immature, clasping husk. In production areas where hand harvest from trees is still practiced, or for varieties in which husks fail to open and allow nut drop, nuts are considered mature when they will rattle inside the husk, indicating detachment of the nut from the base of the husk.

Grades, Sizes and Packaging: U.S. standards exist for filberts in the shell, and for importation of in-shell or shelled hazelnuts, and international UN/ECE standards exist for both in-shell and shelled hazelnuts. Grades are primarily determined by size, degree of kernel fill, color and freedom from defects and foreign material. U.S. No. 1 filberts must contain no more than 20% filberts of a different type (round shaped versus long type); no more than 10% defective nuts, provided that no more than 5% are poorly filled (blanks), no more than 5% are rancid, decayed, moldy or insect injured and no more than 3% are insect injured; not more than 15% filberts that fail to meet the specified size and of which no more than 10% are undersized; shells are free from surface moisture and the combined shell and kernel moisture content is not greater than 10%; shells are well formed, unbroken, not discolored, have adhering husk covering not more than 5% of the shell area and practically free of adhering dirt and other foreign material.

Size is specified in connection with the grade in terms of minimum and maximum diameters which will pass through round openings of a screen and are specified separately for round-type varieties versus long-type varieties. For round-type varieties, Jumbo nuts are those which will not pass through a 56/64 in (22.2 mm) round opening; Large nuts will pass through a 56/64 in (22.2 mm) opening but will not pass through a 49/64 inch (19.4 mm) opening; Medium nuts will pass through a 49/64 inch (19.4 mm) opening but will not pass through a 45/64 in (17.9 mm) opening; Small nuts are all nuts which will pass through a 45/64 in (17.9 mm) opening. For long-type varieties, Jumbo nuts are those which will not pass through a 47/64 in (18.6 mm) opening; Large nuts will pass through a 48/64 inch (19.0 mm) opening but will not pass through a 44/64 in (17.5 mm) opening; Medium nuts will pass through a 45/64 inch (17.9 mm) opening but not through a 34/64 in (13.5 mm) opening; Small nuts will pass through a 35/64 in (13.9 mm) opening.

All hazelnuts imported into the U.S. in lot quantities which exceed 115 lb net weight must meet minimum grade standards as specified under section 8e of the Agricultural Marketing Agreement Act. In-shell hazelnuts must meet U.S. No. 1 grade and be at least medium size with a tolerance for insect injury of 2% or less. Shelled hazelnuts must be well dried and clean, free from foreign material, mold, rancidity, decay or insect injury and free from serious damage caused by serious shriveling or other means. Stated tolerances for shelled hazelnuts include not more than 0.0002% foreign material, not more than 5% of kernels or pieces of kernels which are below grade, including not more than 2% for mold, rancidity, decay or insect injury, and no more than 1% with, rancidity or insect injury.

International grade standards are exercised at the export control stage and are specified for both in-shell and shelled hazelnuts. For in-shell nuts, UN/ECE classifications of Extra, Class I and Class II exist in which the shell of all nuts must be well formed, intact, sound and clean and the kernels must be sound, clean, sufficiently developed, free from: mold, visible damage from insects or pests, presence of live or dead insects or pests, rancidity, foreign smell or taste, and blemishes. All hazelnuts must contain less than 12% moisture and kernels not more than 7% moisture, and foreign material may not exceed 0.25% of the total in-shell weight. Sizing and statement of variety, commercial type or shape is compulsory for Extra and Class I but is optional for Class II. For specified sizes in nuts of all classes, a total tolerance by count of 5% for rounded types and 10% for oblong types for nuts not meeting the specified size is allowed. Extra hazelnuts must be 16 mm in diameter or more and be of superior quality, must be characteristic of the variety and/or commercial type, must be practically free from defects with the exception of very slight superficial defects provided they do not affect the general appearance, quality or keeping quality. They must contain not more than 4% empty nuts on a count basis, not more than 3% of the weight of in-shell nuts may contain shell defects, not more than 5% of the kernels may be defective and of which not more than 3% may be moldy, rotten, rancid or damaged by insects. Class I hazelnuts must be 14 mm in diameter or more and be of good quality, must be characteristic of the variety and/or commercial type, may contain only slight defects provided they do not affect the general appearance, quality or keeping quality. They must contain not more than 6% empty nuts on a count basis, not more than 5% of the weight of in-shell nuts may contain shell defects, not more than 8% of the kernels may be

defective and of which not more than 5% may be moldy, rotten, rancid or damaged by insects. Class II hazelnuts may be of any size (if size is specified, tolerances apply) and be of marketable quality, may contain defects provided that the in-shell nuts retain their essential characteristics as regards general appearance, quality and keeping quality. They must contain not more than 8% empty nuts on a count basis, not more than 7% of the weight of in-shell nuts may contain shell defects, not more than 12% of the kernels may be defective and of which not more than 6% may be moldy, rotten, rancid or damaged by insects. Sizing or screening is used to specify market size in 2 mm increments from 22 mm to 14 mm or less. Sizing for nuts less than 22 mm diameter must include the maximum and minimum size range, or by mentioning the minimum size followed by the words “and over,” or the maximum size followed by the words “and less.” For nuts for final consumers under the classification “screened,” the size “and less” is not allowed.

For hazelnut kernels, UN/ECE classifications of Extra, Class I and Class II also exist and requirements are similar to those stated for kernels of in-shell nuts with the addition of provisions for intactness of kernels and a slightly reduced tolerance for kernel moisture content from not more than 7% for in-shell kernels to not more than 6% for shelled kernels. Foreign material may not exceed 0.25% for kernels in any classification. Sizing and statement of variety is also compulsory for Extra and Class I kernels, but optional for Class II. For kernels in all classes, a total tolerance of 10% is allowed for kernels other than the specified variety and/or type, and a size tolerance by weight of 5% is allowed for rounded types and of 10% for oblong types. To be designated either Extra or Class I, hazelnut kernels must have a minimum diameter of 9 mm, with the exception of hazelnuts of the piccolo type or hazelnuts having a similar designation for which a diameter of from 6 to 9 mm is allowed. Extra hazelnut kernels must be of superior quality, must be characteristic of the variety and/or commercial type and must be practically free of defects with the exception of very slight superficial defects provided they do not affect the general appearance, quality or keeping quality. Total tolerances for defects are 5% by weight or 6% if the lot is specified as “Old Crop.” Of the total tolerance, no more than 1% may be rancid, rotten, moldy, have off odor or off flavor or be damaged by insects or rodents; no more than 2% may be not fully developed, including shrunken and shriveled, stained and yellowish kernels; not more than 3% may be mechanically damaged and pieces. Not included in the total tolerance, not more than 2% may be twin hazelnuts. Class I hazelnut kernels must be of good quality, must be characteristic of the variety and/or commercial type and may have slight defects of form and color, provided that these do not affect the general appearance, quality or keeping quality. Total tolerances for defects are 12 to 13% if the lot is specified as “Old Crop.” Of the total tolerance, no more than 1.5% may be rancid, rotten, moldy, have off odor or off flavor or be damaged by insects or rodents; no more than 4% may be not fully developed, including shrunken and shriveled, stained and yellowish kernels; not more than 8% may be mechanically damaged and pieces. Not included in the total tolerance, not more than 5% may be twin hazelnuts. Class II hazelnut kernels may be of any size (if size is specified, tolerances apply) and be of marketable quality, may contain defects provided that kernels retain their essential characteristics as regards general appearance, quality and keeping quality. Total tolerances for defects are 16 to 18% if the lot is specified as “Old Crop.” Of the total tolerance, no more than 3% may be rancid, rotten, moldy, have off odor or off flavor or be damaged by insects or rodents; no more than 8% may be not fully developed, including shrunken and shriveled, stained and yellowish kernels; not more than 10% may be mechanically damaged and pieces. Not included in the total tolerance, not more than 8% may be twin hazelnuts. Sizing for hazelnut kernels may be by sizing or screening and is expressed in increments of 2 mm. All sizes are allowed, subject to the minimum designations for Extra and Class I hazelnut kernels. For kernels for final consumers under the classification “screened,” the size “and less” is not allowed.

Optimum Storage Conditions: Soon after harvest nuts should be dried to below 10 to 12% moisture, with kernels below 6 to 7% moisture to deter mold growth. In-shell and un-roasted kernels may be stored for 24 mo with minimal loss in quality at temperatures up to 10 °C (50 °F). Roasted kernels may only be held for 6 mo prior to development of detectable rancidity stored at 0 °C, 5 °C or 10 °C (32, 41, or 50 °F).

However, reduced temperature may be effective in combination with other protective measures such as vacuum packaging in extending roasted kernel shelf-life to 1 year or more (Ebraheim et al., 1994).

Retail Outlet Display Considerations: Hazelnuts are normally marketed at ambient temperature. Use of vacuum or low O₂ MAP is recommended to extend shelf-life. In-shell hazelnuts may be marketed in bulk containers. Exposure to moisture and high RH should be avoided.

Chilling Sensitivity: Hazelnuts are not sensitive to chilling temperatures and are commonly stored at temperatures at or below freezing for long term storage.

Ethylene Production and Sensitivity: Ethylene may be used as a harvest aide to enhance maturation of husks for earlier harvest (Lagerstedt, 1979). During storage hazelnuts produce very low levels of ethylene.

Respiration Rates: Properly dried hazelnuts exhibit very low respiration rates during storage.

Physiological Disorders: Black tips on kernels appears to be associated with nuts having split or weak sutures. It appears to be caused by an oxidation process that occurs on the pellicle only, and may or may not be associated with moldy kernels (Thompson et al., 1996). Twin kernels occur when two kernels develop within one nut shell, and is an undesirable trait because of the small size and irregular shape of affected kernels. Blank nuts are in-shell hazelnuts devoid of normal kernels which result from defective embryo sacs, unviable eggs, failure of fertilization or embryo abortion at varying stages of development. Owing to the alternate bearing cycles for hazelnuts, poorly filled nuts may also result during an overproduction year, and poor kernel fill appears to be a heritable trait (Thompson et al., 1996).

Postharvest Pathology: The most common decay found in hazelnuts is molds, with *Romularia* spp. most prevalent throughout nut development and the major pathogen associated with kernel tip mold (see p. 483 of Ebraheim et al., 1997). Although *Romularia* spp. appears to infect hazelnuts during nut development and may be quiescent prior to maturity and storage, many molds require breakage of the shell to contaminate the nut and thus intactness of the shell offers some natural defense against mold infestation. The dominant fungal flora during storage is *Penicillium* and *Aspergillus* spp. *A. flavus* capable of producing aflatoxin has been isolated from hazelnuts in storage (Eke and Goktan, 1987). Reduction of in-shell moisture content to below 10%, and nutmeat moisture content to less than 6% is an effective means deterring mold growth. Sanitation with chlorine dips may also be effective in reducing the incidence of mold infestation by reducing the amount of inoculum carried into postharvest storage. Because of the high amounts of organic material on the surface of shells, chlorine concentrations should be monitored and replenished as necessary to maintain chlorine at concentrations necessary to kill microorganisms.

Quarantine Issues: All trees, plants, cuttings and scions of all species and varieties of the wild and cultivated filbert or hazelnut, *Corylus* spp. may not be transported into Oregon from states and districts of the U.S. east of and including the states of Montana, Wyoming, Colorado and New Mexico; the entire state of Washington, and all provinces, districts and territories of Canada east of and including the province of Alberta to prevent spread of Eastern Filbert Blight (*Anisogramma anomala*).

Special Considerations: Hazelnuts marketed in-shell should be sampled periodically to assess nutmeat quality. Although the most common nut causing allergy in children and adults is peanut, hazelnuts may also be an allergenic food additive (Ewan, 1996) and the presence of hazelnut in foods must be declared. An ELISA test can be used to detect hazelnut presence in complex food mixtures (Holzhauser and Vieths, 1999). Shelling, blanching and/or roasting decreases hazelnut shelflife as compared to storage in-shell

(Ebraheim et al., 1994). Roasting temperature and duration interact to decrease shelf-life with increasing roasting temperature and/or duration (Richardson and Ebraheim, 1997). Hazelnuts absorb lipophilic compounds that can induce off-flavor. Although frozen storage may be used to increase shelf-life, once out of storage hazelnuts should be utilized as soon as possible due to reduced shelf-life at room temperature.

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